Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE PATH OF THE WATER CURRENT IN CUCUMBER PLANTS.

BY ERWIN F. SMITH.

(*Continued from page 457*).

3. DOWNWARD MOVEMENT OF ONE PER CENT EOSINE WATER IN CUT STEMS NOT SEVERED FROM THEIR ROOTS.

(No. 17). This was a young vine, 120 centimeters long, full of blossoms and young fruits and very thrifty; it bore about 24 leaves, the largest five averaging 20 cm. in breadth. March 23, 3:20 P. M. The terminal 12 cm. of the stem was cut away under water and the stump bent over and plunged into 1 per cent eosine water. The sun shone hot and the air of the house was rather dry. 4:20 p. m. No trace of stain in the veins of any of the leaves. March 25, noon. It is now over 44 hours since the cut stem was plunged into the eosine water and judging from the quantity remaining in the bottle no measurable volume has gone down the stem. The external appearance, proceeding from above downwards, is as follows: The first internode (the one in the eosine and just above it) is badly shriveled and diffusely stained. The first leaf (9.5 cm. from the cut end) is not quite as turgid as the rest, and its veins show a faint stain. The second internode (10 cm.) is pinkish green and in the grooves of the stem pink, especially toward the upper end, seeming to indicate that most of the stain has passed through the inner ring of bundles. The veins of the second leaf are also distinctly but faintly pink. The petiole of this leaf is 9 cm. long and its blade 12 cm. broad, and the same pale stain is to be seen in all of the veins. Further down there is no external evidence of stain. The downward movement of the stain has, therefore, been very slight. 1:30 p. m. A long tendril from the second node shows a faint internal stain outward for a distance of 10 cm. On cutting, this is seen to be due to stain lodged in the bundles, while at its base there is also a little diffuse stain. The stain now shows through the interior of the third node which is 9 cm. long. 1:35 p. m. The stem was now cut for examination. The surface of the eosine water in the bottle has not lowered perceptibly. The diffuse stain in the first internode includes everything; the tissues are shriveled and seem to be dead. In the petiole of the first leaf there is a faint stain of the xylem part of each bundle; no diffuse stain into the phloem or any of the tissues outside of the bundle. At the base of the second internode (9 cm farther from the cut stem) the entire xylem of each bundle shows a pale red stain and this has diffused out from three bundles into the surrounding tissues. The second petiole, cut in the middle, shows a faint pink stain, best seen under the lens. It is sharply restricted to the bundles, but occurs in each one and includes the whole of the xylem. At the base of the third internode (9 cm. farther away from the fluid) the stain is fainter and is restricted to the xylem. It is in all of the bundles and is sharper (?) in the spirals of some. Apex of third petiole (down) shows faintest trace of color in 3 bundles, only to be seen under the lens. Color more distinct in the middle part but very faint. Base of fourth internode (9 cm. further from the eosine) there is a very faint stain sharply restricted to the xylem of 6 bundles, all of which is stained. Middle of next lower petiole shows barest trace of stain in two bundles, not visible without a lens. Stain visible in ten bundles of a small fruit from the same node. The base of the next internede (10 cm. further down) shows not a trace of stain. Five cm. farther up, no stain. Additional 3 cm. up, i. e., close under the node, there is a faint stain in the xylem of three bundles and this is not restricted to the spirals. One-half centimeter closer to the node the color is faint and is still restricted to the three bundles.

The stain seems to have travelled in all of the lignified walls, and it appears clear that the spirals did not carry it more than the other woody parts of the bundle. The movement of the eosine water down these stems, contrary to the water current, was scarcely more abundant than the upward movement past the gelatine plugs. Judging from this, the very slow downward movement of the stain apparently follows another law than that governing the rapid upward movement of the transpiration water, i. e., that of surface tension or capillarity.

(No. 19). This was a large old vine, nearly destitute of leaves, the only large one being 8 centimeters below the cut stem. March 23, 4:06 p. m. The tip of this stem was cut under water and immediately transferred to 1 per cent eosine water. 4:15 p. m. No stain in the veins of the first leaf, 8 cm. from the cut. March 25, 12:45 p. m. The leaf, 8 cm. from the cut end, is flabby and its veins show a very decided stain. Farther down there is no stain visible externally. The stem was now removed from the fluid and cut open for examination. At 5 cm. down there was a diffuse stain involving the whole stem, but it was not dense and the bundles were not deeper stained than farther down the stem. At 10 cm. the sieve tube tissue was stained as well as the xylem and there was also a slight diffuse stain into the parenchyma, but the general tone of the stem remained green. At 20 cm. from the cut tip one of the 9 bundles (outer ring) showed no stain. No stain outside of the bundles. At 40 cm. from the cut all of the bundles showed the stain but in one (outer ring) it was much fainter than in the rest. The color was a decided pale red, including the whole of the xylem but not extending to any other part of the stem. At 80 cm. down, the stain was restricted to 4 bundles (the whole of the xylem part) and was barely discernable. At 85 cm. there was still a trace in these bundles—stain in the whole of the xylem and not brighter in the spirals. At 90 centimeters, and farther down, the stain was wholly absent.

This also proved a very instructive stem. The fact that at remote distances the stain was not restricted to the spiral vessels of the stem but tinged the whole xylem equally (the lignified walls) is very striking and decidedly different from the results obtained by passing the stain up the stem, in which case the spirals are stained ahead of the pitted vessels and are clearly seen to be the carriers of the eosine. In this case that portion of the stem in the fluid was not shriveled, probably because it was old and woody.

4. MOVEMENT OF WATER THROUGH BOILED STEMS NOT SEVERED FROM THE PLANT.

(No. 11). A fine thrifty vine, 180 centimeters long, bearing 18 large leaves and half as many more small ones. The largest leaves have a spread of 17 to 19 centimeters. March 21, 4:00 p. m. About 35 cm. from the earth, the bright green stem was bent over and immersed for a distance of 20 cm. in hot water. An attempt was made to boil this water but the heat under the basin was not sufficient, although ample to kill the stem. 4:30 p. m. The temperature of the water during the last half hour has risen from 71° C. to 75° C. There is no change in the color of the immersed part of the stem, nor any change in the foliage above, but the effect of the hot water is already noticeable in the very decided shrinkage of the immersed stem. It has shrunk in diameter nearly one-half. 4:50 p. m. During the last 20 minutes the temperature of the water has risen only one degree. This was now poured out and water at 89° C. substituted. In pouring, the temperature fell to 85° C. In this hotter water the stem quickly became paler green. 4:58 p. m. Temp. of water 80° C. The immersed part of the stem has now shrunk to one-third of its normal diameter, and this shrinkage has extended both up and down, for a short distance out of the water (a few centimeters). 5:15 p. m. Temp. now down to 76° C. Stem taken out. Except the apex of one leaf, 15 cm. up, the foliage did not become flabby. Below the boiled part is a small branch with half a dozen leaves, sufficient to carry the roots. March 22, 11 a. m. The boiled part of the stem, which is now dry and greenish-brown, was wrapped in many folds of rubber cloth. The foliage of this vine shows no wilt, except parts of 5 small leaves, which were near the boiled part and may have been injured by the heat of the lamp. It is windy and sunny and the air of the house is rather dry so that transpiration is active. Temperature in shade, 1 foot above the bench, 26° C. Noon. A check vine (cut off at base, yesterday p. m.) has wilted and shriveled. Temperature three feet above the bench, among the leaves, 30° C. 1:20 p. m. No change. What is especially surprising is that the tender terminal leaves show no signs of wilt. 4:15 p. m. This vine has stood up remarkably to-day. The transpiration demands have been large and there has been no wilt—not a trace—that mentioned as occurring on a few of the small basal leaves being evidently due to imperfect protection from the heat of the lamp when the stem was boiled. March 23, 11 a. m. Sunny and hot; some wind; air of the house rather dry, and transpiration large. No wilt of the foliage except the margins and tips of the blades of three big leaves midway up the stem. These are slowly drying out. 12:30 p. m. The greater part of the foliage on this vine is still turgid and normal in appearance. The tips and margins of the three leaves above mentioned are crisp, but this injury involves only a small part of each leaf. Transpiration active. Temp. in sun 30° C. Dry bulb 26.5° C.; wet bulb 22° C. 3:00 p. m. Slight, if any, change. Nearly all of the leaves are turgid and entirely normal in appearance, including all at the top of the vine. 4:20 p. m. No change since the last record. The vine stands up well. Temp. now 24° C. Active transpiration all day. March 25, 1:15 p. m. The vine stands up well. Nearly all of it is perfectly healthy, including the tender upper part, but portions of the lower leaves already mentioned are slowly drying out and in a very interesting manner, i. e., after the fashion of the California vine disease, the larger veins and their branches and a little of the adjacent parenchyma remaining green, even dark green, while the parenchymatic areas between the veins, especially at the apex of the blades and on the margins, are becoming first yellow and then a dead brown. 5:30 p. m. Vine stands up beautifully. It is four days since the stem was killed by the hot water. March 26, 2:45 p. m. A great change for the worse since yesterday. All of the foliage has now wilted (as yet only the blades) and the large leaves midway down as well as the smaller lower ones are rapidly drying out. March 27, 1:20 p. m. All of the leaves are now crisp, except a few very small flabby ones which are in the vicinity of a half grown fruit from which they are drawing water. The stem is still turgid but some of the petioles begin to droop.

The leaves below the boiled part are still healthy. March 28, 1:30 p. m. The stem and the petioles are still green but the latter are becoming more and more flabby, most of them at the top of the vine having lost all of their turgor.

This vine was able to draw all the transpiration water necessary to supply a large leaf surface (more than 3.000 sq. cm.) through about 25 centimeters of dead stem for a period of four days, during a part of which time the transpiration was very active. All of this water must have passed up through the bundles, since all the outer parts were dead and dry and shriveled down onto the bundles, the vessels of which preserved their shape unaltered as shown by subsequent examination.

(No. 13). This vine was 130 centimeters long. It bore six small leaves and 12 large ones, the best averaging 17 cm. in breadth. March 22, 1:02 p. m. The stem was bent over near the earth and inserted for a distance of 18 centimeters into water at 90° C. In two minutes the temperature rose to 95° C. 1:07 p. m. Water simmering; temp. 97° C. Boiled part not yet noticeably smaller. 1:10 p. m. Stem shows shrinkage and change of color. 1:15 p. m. Slight loss of turgidity in most of the leaves. 1:20 p. m. A marked shrinkage of the diameter of the stem is now first visible. The flabbiness of the foliage is increasing rapidly, every leaf is affected. 1:27 p. m. Water has remained at 97° since last record. Stem taken out because of the marked wilt of the foliage. This wilt appears to be due to the transpiration of hot water. The wilt is too sudden and decided to be due to anything else. The stem has not only shriveled in the water but also for a distance of 10 cm. up and 5 cm. below, making a total of 33 cm. of dead stem. Sun hot; earth and air of house rather dry; transpiration active. Such an experiment were better tried when the air is nearly saturated and transpiration slight. 1:45 p. m. Stem wrapped in many folds of rubber cloth. Roughly estimated it has shrunk to about one-third its normal diameter. The leaves seem to be recovering their turgor.

2:00 p. m. The lowest leaves are still flaccid but the upper ones have fully regained their turgor. 3:45 p. m. The lower leaves have now also regained their turgor. Its loss was clearly due to the transpiration of hot water. (Subsequent experiments showed that it is very easy to push this wilting beyond the power of the plant to recover). 4:15 p. m. The plant stands up well. There is no trace of wilt. March 23, 11 a. m. No sign of wilt. Noon. The lowest five leaves show distinct signs of wilt at the tip of the blade. None of the upper leaves show any trace of it. 12:25 p. m. The wilting is worse but is still confined to the lower leaves. It is very decided on the lowest one which is exposed to the bright sun. The tender apical leaves are turgid, as well as those in the mid part of the stem. 1:20 p. m. The leaf next to the lowest one begins to crisp. 3:00 p. m. Blade of lowest leaf but one is now crisp, and the blades of the other four are drying out at the apex and on the margins and between the larger veins. 4:30 p. m. No change. The bulk of the foliage stands up well, including all of the upper leaves March 25, 1:20 p. m. The lower leaves of this plant are dried out to a greater extent than are those of No. 11, but the major part of the foliage is normal and the tips of both vines are noticeably turgid. The drying out of the parenchyma between the veins is also to be seen in the affected leaves of this vine, the larger veins and a narrow border of the leaf parenchyma remaining a bright green. 5:40 p. m. The vine stands up well. It is three days and four hours since the stem was boiled. March 26, 3:00 p. m. The vine begins to show symptoms of collapsing. All of the petioles are turgid, but the blade of the lowest leaf is nearly dry, that of the next up is wholly dry; those of the next three above are crisp at the apex and on the margins (one-fifth to one-third the surface); the three next up show a trace of drying on their margins, and in all the rest there is a faint suggestion of loss of turgor. March 27, 2:00 p. m. All of the leaves on this vine are now crisp-dry except three at the top which are flabby. The stem and the petioles are still turgid. March 28, 1:30 p. m. The upper three leaves are still flabby, and all of the petioles are still rigid except the tips of some of the lower ones which begin to droop.

This vine gives results confirmatory of the preceding. For more than three days the plant was able to draw all of the water necessary for its use through 33 cm. of dead stem. Probably if air could be prevented from gradually passing through the shriveled stem into these water carrying vessels and interfering with the normal condition of things the plant might continue to draw its water through a dead stem almost indefinitely.[1]

5. THE RESULT OF PARASITIC PLUGGING OF THE VESSELS.

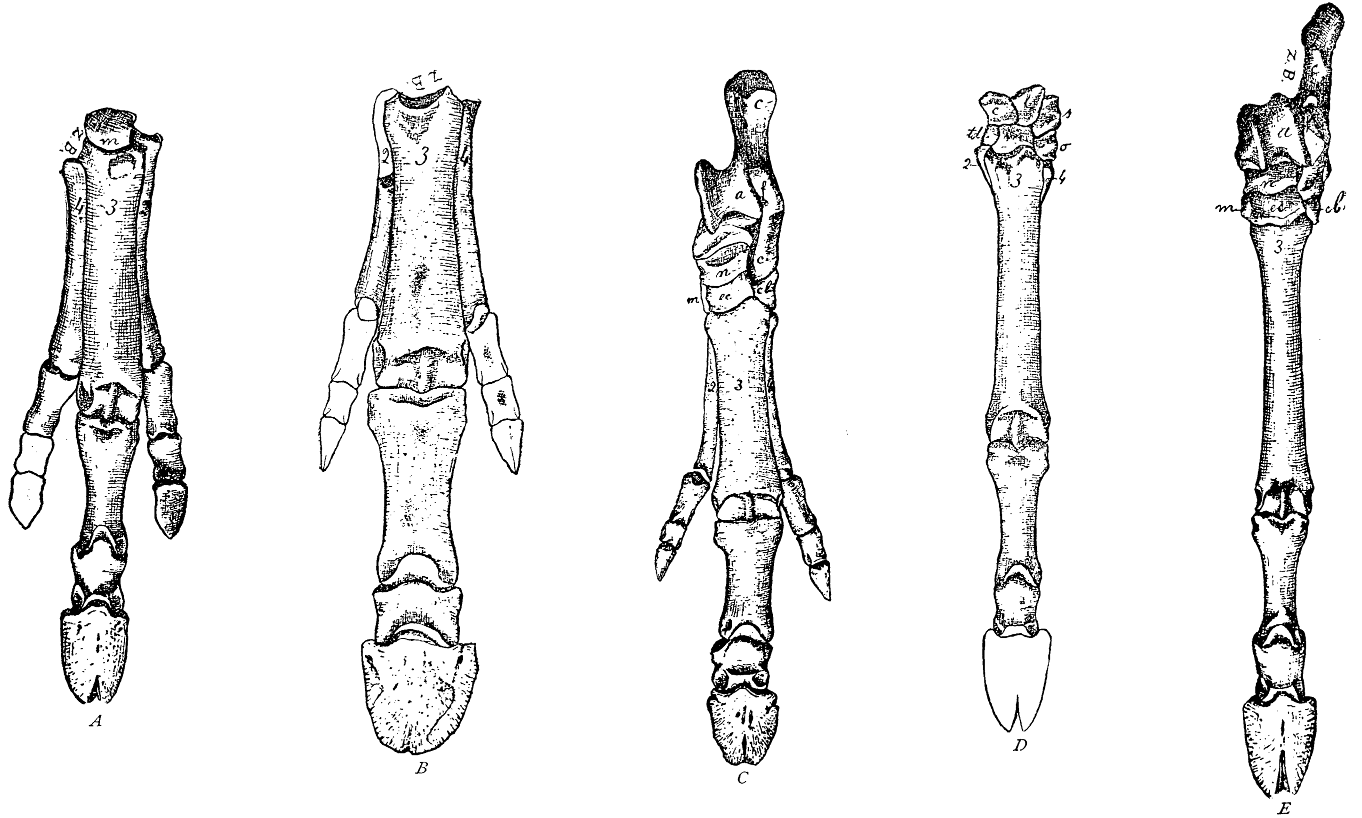
From these experiments and those upon the cucumber wilt, which I have published elsewhere, it follows that the downward path of *Bacillus tracheiphilus* from the inoculated leaf blade into the stem of the cucumber (for an account of this disease see *Centr. f. Bakt. u. Par. Allg.* I, No. 9–10, 1895) is exactly that made use of by the ascending water current, just as I stated it to be at the Brooklyn meeting of the A. A. A. S., and the general wilt of the foliage may be explained, first, by a functional disturbance, due to the more or less complete clogging of the lumina of the spiral vessels with countless millions of these bacteria which thrive in the alkaline fluid of the vessels, and, second, by a structural disturbance, due to the breaking down (dissolving) of the walls of these spirals and the flooding out and subsequent growth of the bacteria in the surrounding parenchyma and in the pitted vessels, accompanied, of course, by the more or less free entrance of air into the spirals. It is probable, although not enough examinations have yet been made to render this certain, that no leaf wilts from secondary infection until the water carrying spirals in its petiole have become clogged by the bacillus, i. e., that the wilt of the leaf is not induced by the partial clogging of the vessels farther down in the stem. This is the more likely, first, from the fact that there is always a progressive wilt, leaf after leaf, beginning with the ones nearest the point of infection and moving both ways therefrom, and, second, from the fact that very rarely are all of the pitted vessels filled, so that water lifted up from the roots has always the opportunity to pass around the clog in the spirals by way of the unfilled pitted vessels and to enter the spirals once more farther up. Were this not so, i. e., were pitted vessels filled as readily, as quickly, and as fully as the spirals, we should have not the gradual wilt of leaf after leaf up and down the stem, but the sudden collapse of all the leaves beyond the original point of attack. This is exactly what does happen in watermelon vines attacked by *Fusarium niveum*, (for a brief account of this parasite see *Proc. Am. Asso. Adv. Sci.*, Vol. 43, 1894, p. 289, and *Ibid*, Vol. 44, 1895, p.   ) where the pitted vessels appear to fill with the fungus as soon, if not sooner, than the spirals.

---

[1] Those who wish to follow these subjects may consult the above mentioned work by Strasburger, pp. 510-936, where many interesting experiments are detailed.

These two diseases of cucurbits are very interesting from a physiological standpoint, and both parasites lend themselves readily to infection experiments, their slightly different behavior being, perhaps, accounted for by the fact that the fungus is strictly ærobic, while the bacillus is facultative anærobic. Whatever be thought of butter or gelatine, it certainly cannot be maintained that the mere presence of these parasites in the lumina of the vessels destroys the carrying capacity of the uninjured walls, and yet they act quite as effectually as gelatine, paraffin, or cocoa butter plugs, causing, when they fill the vessels only incompletely, a flabbiness of the foliage, which is proportionate to the extent of the plugging and to the activity of the transpiration, and which may give place to complete turgor in periods when the transpiration is small (night, early morning, or damp days), and producing, when they completely fill the lumina of the vessels, an entire collapse of the foliage, from which there is no recovery. In case of the cucumber this collapse takes place as soon as the spiral vessels leading into any petiole are filled by the bacillus.

PLATE X.



Feet of Proterotheriidae from Ameghino. A, fore foot of *Proterotherium cavum* Amegh. B-C, Fore and hind feet of *Diadiaphorus majusculus* Amegh. D-E, Fore and hind feet of *Thoatherium crepidatum* Amegh.